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Another interesting feature of these books is the free use which is made in qualitative explanations of such conceptions as the kinetic theory of gases, the ionic theory of electrolytic conduction, and the wave front in geometrical optics. Whether or not it pays, for instance, to displace the old ray-optics, which must, of course, be properly interpreted, by the more valuable but also more difficult notion of the wave front, is a question of pedagogy which each teacher must decide for himself. Fortunately the treatment of the most dangerously spectacular part of our modern physics is confined to the last twelve pages of the text-book, where there is an account, admirable as regards both interest and conservatism, of vacuum tube phenomena and of radio-activity, including some of the evidence for the existence of electrons, together with brief statements of the corpuscular theory of matter and of the disintegration theory of radio-activity.

Many other features, while not unique, are nevertheless worthy of much praise. For instance, the experiments, both for the laboratory and for the lecture room, are ingeniously simple and yet, so far as one can judge without trying them, entirely effective.

The typography is good, and the illustrations are most excellent, both in technique and in conception; and the sixteen full-page half-tones of eminent physicists, each with a short paragraph describing the man's life and work, are a notable addition not only to the attractiveness but to the real value of the books.

H. N. D.

BIOLOGY.

Jennings' Behavior of the Lower Organisms.¹—It is now nearly a decade since Professor Jennings published his first brochure on the reactions to stimuli in unicellular organisms. The intervening period has been one of continuous activity on his part in the study of animal behavior, especially among the lower organisms. His investigations have not been strictly confined to the Protozoa for among the score or more of titles of important contributions from his

¹ H. S. Jennings. *Behavior of the Lower Organisms*. Columbia University. Biological Series, New York, The Macmillan Co., 1906, 8vo, xiv+366 pp., illus. \$3.00.

pen are studies of the reactions of *Metridium* and of rotifers. Nor have his investigations been limited to the animal world alone for groups on the border lines such as the flagellates and bacteria have also been included. All students of these groups and especially investigators of animal behavior and workers in the field of comparative psychology will find cause for congratulation in the fact that Professor Jennings has taken this opportunity to resurvey the whole field of his experimental work and to summarize and restate his conclusions in this most important field of research. While many studies in this field have been made primarily from the standpoint of the psychologist, or have been of a desultory character, or are but partial in scope, the work summarized in this book has been dominated by the broadest scientific spirit, has been conducted with the greatest care and thoroughness, has included in its scope all possible avenues of approach to the analysis of animal behavior, as exemplified in the simplest organisms, and has been carried through to a stage of completion where fundamental generalizations are possible. The work of others in this field whether in agreement or not, with the author's conclusions, is treated with fullness and fairness. The book thus becomes an exemplification of the value of intensive research, an indispensable authority for any who wish to become familiar with the latest results in the field of animal psychology. As illustrative of the thoroughness with which the analysis has been carried out we find that in *Paramecium* the structure and the normal movements are described and correlated, and the reactions to chemical and mechanical stimuli of various sorts determined, the absence of reaction to light but the sensitiveness to the ultra-violet rays noted, as are also the reactions to heat and cold, to induction shocks and a constant current of electricity, to water currents, gravity, and centrifugal force. The relation of these actions of orientation to other reactions is carefully analyzed. The behavior of *Paramecium* in daily life in the aquarium, in fission and conjugation, under two or more stimuli, are all passed in review and the variability and modifiability of reactions is determined. The author concludes from observations on the differences in behavior of individuals that we find in *Paramecium* slight beginnings of the modification of behavior through the previous experiences of the organism. In the case of *Stentor* the same individual does not always behave in the same way under the same external conditions, but the behavior depends upon the physiological condition of the animal. The reaction to any given stimulus is modified by the past experience of the animal, and the modifications are regulatory, not

haphazard, in character. The phenomena are thus similar to those shown in the "learning" of higher organisms, save that the modifications depend upon less complex relations and last a shorter time.

Each organism is found to exhibit a set of actions made up, in the case of the lower organisms, of a few factors combined in various ways in a coördinated system which Professor Jennings designates as "the action system." For the term "motor reaction" employed in his earlier papers the phrase "avoiding reaction" is now used to designate the stereotyped method of reaction of Infusoria to most stimuli. The author rejects the local action theory of tropisms as a "more or less artificial construction, made by combining certain elements of behavior and omitting others that are of most essential significance." In its place he proposes the method of "trial and error" as an explanation of behavior. The stimulus interferes with definite internal processes occurring in the organism and this interference causes a change in behavior and varied movements which subject the organism indiscriminately to many different conditions. It merely acts in all sorts of ways possible to it. When one of these new conditions thus met relieves the organism from the existing interference with its life processes, the trials cease.

As a second cornerstone in the formulation of behavior we find the law of "resolution of physiological states" thus stated: "The resolution of one physiological state into another becomes easier and more rapid after it has taken place a number of times." It appears that even in *Stentor* and *Vorticella* repetition of an action brings the second step in a sequence in behavior more quickly upon the first. Here lie the foundations of the phenomena which are usually designated as habit formations, memory and learning, and the question may well be asked whether they are not coëxtensive with life and based fundamentally on the physical and chemical structure of colloids.

C. A. K.

Modernized Darwinism.¹ — Professor Guenther has written a very readable book on Darwinism and allied biological problems which the tyro will find quite intelligible. The translation seems good and the publishers have done their part well. The treatment of the subject is rather novel, most of the chapters being divided tax-

¹ C. Guenther. *Darwinism and the Problems of Life*. Translated from the third edition by Joseph McCabe. London: A. Brown & Co., 1906, Dutton & Co., New York, American agents. 8vo, 439 pp.